sunchill

re[bound] ENERGY INSTITUTE Colorado State University TECHNOSERVE BUSINESS SOLUTIONS TO POVERTY Moçambique Orgânicos

Preparation Trip #1
June 25 – July 14, 2014

This product is made possible through the support of the Powering Agriculture: An Energy Grand Challenge for Development Partners: the United States Agency for International Development (USAID), the Swedish Government, Duke Energy, and the German Federal Ministry for Economic Cooperation and Development (BMZ). It was prepared by Rebound Technology and does not necessarily reflect the views of the Powering Agriculture partners. Further information about Powering Agriculture can be found at www.PoweringAg.org

POWERING AGRICULTURE: AN ENERGY GRAND CHALLENGE FOR DEVELOPMENT

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1. Introduction

As part of the Powering Agriculture project, Rebound will send a team to Mozambique in April 2015 to build and deploy a demonstration SunChill system. This final phase will only proceed once a prototype is designed, built, and tested in Colorado. In preparation for the move to Mozambique, Rebound scheduled two 'Preparation Trips' in 2014 to accomplish the Objectives listed in Section 2. The first of these trips took place from June 25th – July 14th. This report documents the objectives, discoveries and networking that resulted from Preparation Trip #1.

2. Objectives

The objectives of this trip were as follows:

Technical Objectives

- Visit Mozambique Organicos, the primary demonstration location.
- Visit other potential demonstration locations.
- Determine necessary design features based information collected from partners and others in agricultural/NGO community.

Business Model Objectives

- Validate proposed value proposition.
- Investigate potential business models.

Logistical Objectives

- Meet partners: TechnoServe and Mozambique Organicos
- Investigate manufacturing and procurement options
- Investigate living/accommodation options

Networking Objectives

- Network with Mozambique agricultural community.
- Network with Mozambique NGO community.

Media Objectives

- Collect still image and video footage for project PR.

3. Itinerary

Russell Muren and Kevin Davis arrived in Mozambique and went immediately to the Inhambane Province for 10 days. This was followed by eight days in Maputo. Below is a detailed description of the itinerary.

Inhacoongo: This is the location of Mozambique Organicos, located about 55 km south of the city of Inhambane and 424 km north of Maputo. June 26-30th were spent in Inhacoongo learning as much about Mozambique Organicos operations as possible from Koos van de Merwe, the founder and operator.

Maxixe: Project partner, TechnoServe, has an office in this city, siting across the bay from Inhambane City. Alexandre Negrão, an expert in citrus fruit and a lifelong entrepreneur, manages TNS in Maxixe. Alex has founded/supported many agricultural operations in Mozambique and spent 2 days with the Rebound team introducing us to the region from July 1-2.

Tofo: Rebound spent July 3-4 working from a beach town located 20 km from Inhambane. While there, the team did explore the local agricultural supply chain, but mostly spend the hours working on SunChill and non-SunChill related tasks.

Maputo: After a daylong commute by car to the capital, Rebound spent the next eight days working from the TechnoServe office and meeting with contacts. Russell Muren remained in Maputo until July 8th and Kevin Davis remained until July 14th.

4. Partners & Networking

While in Mozambique, the Rebound team spent time meeting partners and networking with various organizations in Maputo to better familiarize themselves with the work being conducted and the obstacles related to cold chain implementation.

Mozambique Organicos – Rebound had an opportunity to meet with our project partners in Inhacoongo, the location of the for-profit/research farm, Mozambique Organicos (MO). The Rebound team had previously been communicating via email with Koos van de Merwe, the founder of MO, but getting an opportunity to spend four days learning about his operations was incredibly helpful. See the Discovery section for more details.

TechnoServe – Similar to the situation with MO, most of the communication with project partners TechnoServe (TNS) had been via email and Skype. Getting an opportunity to spend time with the TNS team was incredibly helpful, especially the two days spent up in Maxixe with Alexandre Negrão. Alex is a born and raised Mozambican, of Portuguese decent, who is a citrus expert and a life-long entrepreneur. While his current role with TNS assists other organizations, this skill comes from the various businesses, both in agriculture and other sectors, that he's founded throughout his career. Rebound also had the opportunity to meet the TNS staff in Maputo, all of whom were helpful and willing to excited to assist moving forward.

USAID Mission – While we did have an opportunity to meet with the mission, the coordination on their end was poor due to a mission-wide deliverable on our meeting day. While they expressed interest in a follow-up meeting later in the week, all attempts to schedule a meeting with the agricultural focused mission members failed. Either they were busy or uninterested. The Rebound team did get some helpful information from Michael Jordan, Senior Advisor in the Office of Agribusiness, Trade & Business, who was introduced to Rebound by Louay Samouie.

IIAM: Rebound had the pleasure of presenting to Hipólito Alberto Eduardo Malia, an Assistant Researcher for IIAM, working on a food security project. Hipólito was very interested in the technology and made an introduction to Jennifer Cairns, a Michigan State University researcher working on socio-economics component of the Trilateral Horticultural Project (Mozambique-Brazil-US). The data acquired by IIAM will help Rebound with design/implementation decisions.

GAIN: Rebound met with Daniel Alberts from the Global Alliance for Improved Nutrition, who have selected 15 agricultural projects over the past year to receive funding, a few of which are cold chain related. Daniel has offered to put Rebound in touch with those project leaders to determine if, in the future, there is possible synergy.

WWF-CARE: Dave Besch from DAI put Rebound in touch with Dan Mullins, the Africa Program Manager for the WWF-CARE alliance. Dan mostly works on mitigating coastal over-fishing by expanding access for Mozambican fishing to more distant waters. That said, Dan has been in the region a long time, had great advice and introduced Rebound to Kenmare, an Irish-run mining operation in the north near Nampula.

Kenmare: Dan Mullins put Rebound in touch with George Clifton of Kenmare Mines to better understand how they feed 1600 employees daily and what type of programs promote the procurement of local horticultural products. Rebound met with Regina Macuácua, the Community Relations Superintendent who helped explain the catering logistics.

Bechtel: Kevin Davis was introduced to Christopher Dell, through a friend working in Kosovo for Bechtel. Chris Dell was a 30-year diplomat, the US Ambassador to countries such as Zimbabwe, Angola, and Kosovo, who decided to move to the private sector. He is now the Country Manager for Mozambique and exploring potential oil and gas opportunities in the country. As part of any proposal, Bechtel would like to include, like Kenmare, local product procurement programs.

Land O'Lakes: This food processing organization has an international development division that has chosen Mozambique as one of their target countries. Fidel O'Donovan, Chief of Party, met with Rebound to discuss their particular obstacles related to the cold chain. All of their work focuses on milk production, which isn't the primary focus of the SunChill technology, but a sector that could be investigated once the horticultural version of the technology is fully validated. Rebound suggested Fidel speak with other recipients of the Powering Agriculture grant such as Promethean and SunDanzer.

5. Discovery

Going into the SunChill project, the Rebound team had envisioned a mobile system, moved from farm-to-farm, field-to-field, cooling horticultural products from their field temperature to storage temperature. Rebound did not have a solution for the second link the cold chain, such as a cold storage room, but envisioned SunChill adding value regardless. The Rebound team discovered that the independent value add was overestimated.

Discussions with Mozambique Organicos, immediately after arriving in Mozambique, indicated that cooling products down to storage temperatures adds value, but only if you have cold storage immediately afterwards. Otherwise, all that value is lost. To be more explicit, SunChill needs to be deployed, in tandem, with cold storage.

Technical Discovery

From a complete cold chain perspective, utilizing SunChill to drop product temperatures from harvest levels (25C) to storage levels (4-10C) serves the following primary function: **it enables the implementation of inexpensive cold storage by reducing necessary equipment size and electrical needs.**

One of the reasons cold storage isn't prevalent in Africa is cost. Even where there is electricity and a stable grid, capital /operating costs become the primary obstacle. One of the reasons for such high expenditures is that cold storage rooms are conducting two steps, cooling and storage, when they ideally should only be designed for the latter. Cold storage rooms primarily spend time maintaining low temperatures, an effort taking approximately 0.4 W of cooling power per kg of product (W/kg). Unfortunately, freshly harvested products must be cooled in 6-12hr, an effort that A) requires 3.5 W/kg and B) dictates the required refrigeration system size. As a result, system costs are 9X higher than they would be if the two steps were separated into optimized processes, one for cooling and another for storing.

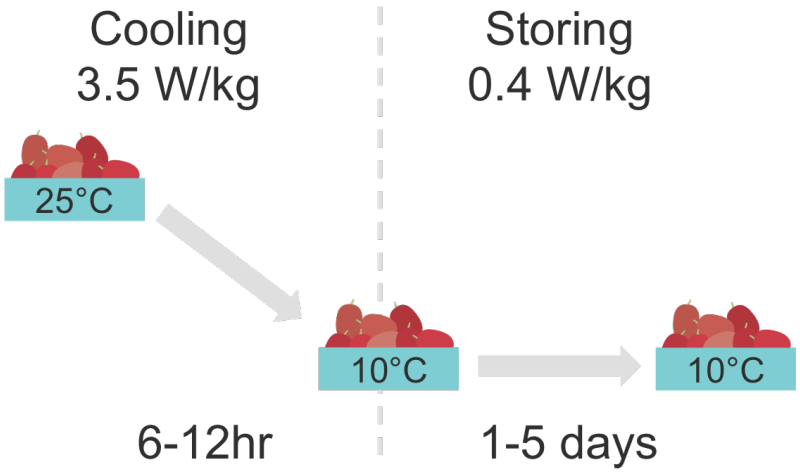

Figure 1: The two steps current cold storage rooms are required to perform.

SunChill provides the cooling step at a higher efficiency and using off-grid power so that cold storage rooms with smaller components can be utilized. Reducing compressor, evaporator, condenser and backup diesel generator sizes mitigates capital costs. Additionally, equipment capable of supplying 0.4W/kg of cooling can be purchased and maintained locally using equipment like remote condenser AC units, equipment available in rural Mozambique locations.

Reasons cold chain is unavailable:

- Cold storage equipment must provide 3.5 W/kg when cooling products, but only 0.4 W/kg when storing products.
- Cold storage equipment is sized by power and, unfortunately, farmers must buy units capable of providing 3.5W/kg despite operating them at this power level for just 5% of the time products are in the cold room.
- The energy required to cool 1kg of tomatoes is equal to the energy required to store those tomatoes for 2.5 days (economically, a kg of tomatoes can be stored for 2.5 days before the storage energy cost surpasses cooling energy cost).
- Cooling is time critical and can't be provided by an intermittent power supply. However, storage can weather intermittent power supply issues from grid or solar inputs.

Impact on availability of cold chain:

- Cooling power (main cost of cold storage) is reduced from 3.5W/kg to 0.4W/kg.
- More available equipment, such as AC units, can replace industrial compressors, expenders, etc. to maintain the necessary storage temperatures.
- Total power consumption for five-day storage cycle is reduced by 23%.
- Cooling using SunChill is significantly more robust and can supply the required cooling power regardless of power supply.

Other technical discoveries related to the SunChill technology were:

- Flat plate and evacuated tube solar collectors are available in Mozambique. While not manufactured domestically, there are Chinese and South African options.

- Reductions in necessary electrical load for cold storage rooms might enable off-grid options such as solar with some form of storage, either electrical or thermal.
- AC units with remote condensers, a potential cold storage solution, are prevalent in Inhambane province of Mozambique.
- Although grid connection is possible, backup generators are still required and represent a large upfront capital cost to potential commercial scale farmers.

Business Model Discovery

From a business model perspective, SunChill must be sold to people, organizations or local governments with financing. Based on discussions in Mozambique, the following are some potential options:

Medium-Sized Farms: Currently, in Mozambique, even medium sized farms, run by ex-patriots, don't have the funding to own/operate a cold storage facility. SunChill, as described earlier in this section, can enable cold storage implementation by decreasing associated costs. In this scenario, products harvested on the farm and by local outgrowers are brought to a central site, run through the SunChill system and then immediately put into a cold storage unit. The result is higher quality products.

Farmer Associations: Very similar setup as the previous. Products are brought to a central facility, cooled with SunChill and stored in a now affordable, cold storage facility.

Large Farms: While this option won't directly impact smallholder farmers, it is important to acknowledge that from an energy savings perspective, larger farming organizations might be very interested. This could potentially serve as a validation option.

Catering: Mozambique is a country rich in natural resources, mainly of interest to those organizations focused on extraction. Whether minerals, oil or natural gas, these very large facilities require employees and employees require food, but unfortunately, most is flown in from abroad. These organizations A) want to reduce costs and B) would love to have the local communities benefit from their demand. Please see the Validation Plan section for more information.

Local Markets: While Rebound only visited a handful of local markets, it's very clear that there is often space for the implementation of a cold storage room. In an organized space, where the local government already rents out stalls to vendors, a system could be put in place where, in the evenings, products are passed through SunChill and then into cold storage. In Inhambane, women are already familiar with paying 5 mt (US$0.16) per kg for storage of fish overnight. This could work in a similar manner, but with refrigeration, not freezing. The owner would either be the local government, a third party service provider or Rebound. More work must be done to determine if women would truly use the service. After all, there exists a cold room at the Maputo Central Market and the individual who operates the service says the women barely use it. They want things for free and don't understand the business benefits of refrigeration. Once again, this is a difficult path and not where initial validation will take place. See the Validation Plan section for more details.

6. Validation Plan

Beyond the demonstration, which will primarily occur at Mozambique Organicos, its important to recognize that the go-to-market strategy won't be the local market path mentioned in the Discovery section. Instead, validation will occur among those in the agricultural community educated about cold chain benefits and with the ability to pay for them. This leaves medium and large sized farms,

farmer associations and large catering companies. Its very clear that A) there are limited sales opportunities among this group and B) the extent to which it directly helps smallholder farmers is unknown. However, new technologies require early adopters and, in the case of refrigeration, those early adopters won't be the local markets.

Moving beyond early adoption, the goal is to expand sales opportunities and the extent to which smallholder farmers benefit from them. For instance, once the technology is proven at the early adopter level, perhaps local governments and women selling products at local markets will become educated on and accepting of the refrigeration benefits. Similarly, perhaps the technology helps advance outgrower schemes. After all, if a farmer now has the ability to sell higher quality products as a result of cold storage, perhaps that farmer will be encouraged to increase production via outgrowers.

There are many unknowns, but what's clear is that the first market to tap, is the educated farmer. After validation, more options become available.

7. Cold Storage Example

The SunChill proposed SunChill value proposition is the ability to insert already pre-cooled horticultural products into a cold storage room thus greatly reducing the equipment size and electrical needs to maintain that temperature. The content that follows is a quantifiable example to help portray the SunChill benefits.

This particular example analyzes the equipment size and energy consumption required to cool and store vegetables, with and without SunChill pre-cooling.

Values (per kg of cooled product)	**Cold room without pre-cooling**	**Cold room with SunChill pre-cooling**
Cold Storage Capital Cost		
Compressor Size (Electric)	0.62W	0.07W
Evaporator Size (Thermal)	3.58W	0.37W
Condenser Size (Thermal)	4.20W	0.44W
Diesel Gen Size (Electric)	0.62W	0.07W
Estimated System Cost	**$5.01**	**$0.51**
SunChill Capital Cost		
SunChill Size (Thermal)	0W	21W
SunChill Cost	**$0**	**$4.00**
Annual Electrical Consumption		
Cooling to 10°C	800Wh	0Wh
24hr of storage at 10°C	548Wh	548Wh
Electricity Cost	**$0.36**	**$0.15**
Total Cost 1 year	**$5.37**	**$4.66 (13% savings)**
Total Cost 10 years	**$8.61**	**$6.01 (30% savings)**

Assumptions: Cost of diesel generator $0.21/W, Cost storage equipment $1.36/W, 216 harvest days/year, 365 storage days/year, cost of electricity $0.27/kWh

8. Preparation Trip #2

The Rebound team will return to Mozambique prior to the end of 2014 to continue preparations for Phase III, beginning April 2015. Rebound's new, SunChill dedicated employee will be visiting Mozambique in preparation for their long-term return to the country next year. During this trip, more specific details will be determined such as:

- Living/Work location during prototype development in Inhambane
- Living location during prototype demonstration in Inhacoongo
- Vendor search for small pumps, solar collector and other balance of system supplies

8. Photos

Russell Muren explaining the details of SunChill to Alex Negrão (left) and Koos van de Merwe (Mozambique Organicos).

Current compressor and condenser for MO cold storage room.

View of loading dock, MO cold storage (left) and processing room (right).

MO cold storage room. Oversized to cool as well as maintain storage temperatures.

Processing room at MO where products packaged.

Refrigerated truck picking up purchased products from MO.

Koos van de Merwe explaining the farms organic cow nutrition program and resulting composting.

MO has 50 ha of land plus receives products from supported, smallholder farmers in the area.

Tomatoes in a local market. Very ripe (left) fruits sell for less than less ripe fruits (right).

Road-side fruit and vegetable vendor in Inharrime.

Vendors with rented stalls in Inhambane.

Solar water heater for yogurt production near Inhambane.

Strawberry farm near Inhambane. Another potential demonstration site.

A local farmer making a delivery of tangerines at serious risk of thermal/mechanical spoilage.